Urban Flood Reconstruction Using Bloggers' Posting on Road Inundations

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Abstract

This paper was an attempt to suggest that bloggers' information, after being judged rationally, would be a huge contribution as part of the compilation of flood information system. Immediately after a flood event in January 2009, bloggers in Kuching, Sarawak had posted their "personal diaries" on the internet along with a collection of photos. They may write leisurely, but unaware, they had provided valuable information on the flood event. As demonstrated, flood depths in roads adjacent to Sarawak River were identified spatially by referring to three blog sites carefully selected to be the figures of merit. With the availability of such data at eleven locations, a 1-D river model was set up to have a flood mapping extended to include other parts of the city centre with relative ease. The bloggers' information is argued here as a source of data potential to improve the flood data collection and management.

Keywords

Blog; Flood Depth; Flood Mapping; InfoWorks RS; River; Urban

Background

Flood reconstruction can be defined as a scientific process of re-collecting the characteristics of flood (Bradzil et al., 2006), particularly of extreme events (Wolfe et al., 2006). It is useful tool for the study of flood risk to investigate the vulnerability of societies and economies confronting extreme hydrological events (Kates et al., 2006). Traditionally, reconstruction after a flood event in an urban setting requires recorded hydrological data (e.g. water level readings along an important river (Zhou et al., 2002)) and water marks left on sites or buildings (Benito et al., 2004). Then the levels of floodwaters are traced on a map manually, which is a tedious work. Analysis nowadays involves software (Lapointe et al., 1998), in which computer modelling is a resourceful approach to address flood risk assessment. There is currently rapid growth in the area of integrated urban flood modelling, with a large body of material on developments in the flow models, data accuracy and correction (Hankin et al., 2008). Yet, 1-D computer models, both hydrological and hydraulic concentrate on the conveyance of flood flow in the river channel rather than the floodplain areas. Overbank flow is an interpolation from flow of main river channel. In most developed countries, though 2-D modelling has been available for many years, it remains unaffordable technically and financially for many third world countries. One of the common technologies, remote sensing imaged overbank flooding when combined with topographic information permits measurement of flooded ground profiles (Bates et al., 1998). It has been seen based on the authors' experience that most authorities in developing countries rarely own any captured satellite imageries during flood events and it is a costly effort to seek one from an imagery provider for research purposes. As normal practices, the authorities would send out officers during flood to record those levels at chosen and limited locations. Therefore, it is presented in this paper that a blogger's posted information can be argued as a new source of data that provides valuable information during flood episodes.

Kuching City of Sarawak State, Malaysia is located on a flat alluvial coastal plain about 30 km away from the South China Sea (see Fig. 1). The Sarawak River subdivides the city equally into North and South Banks. Due to its establishment on the river floodplain, the flood risk is significant due to fluvial and tidal events (Memon and Murtedza, 1999; Sharp and Lim, 2000; Putuhena et al., 2005). Heavy rain continuously over four days starting from January 8 till 11, 2009 had heavily damaged the city. The Sarawak State Government had officially announced the daily total rainfall for the four consecutive days as 64, 54, 225 and 205 mm, respectively. Upstream flows had contributed to the rise of Sarawak River water levels and bank-bursts along the river corridor. The highest tide level was recorded at 6.2 m at estuary.

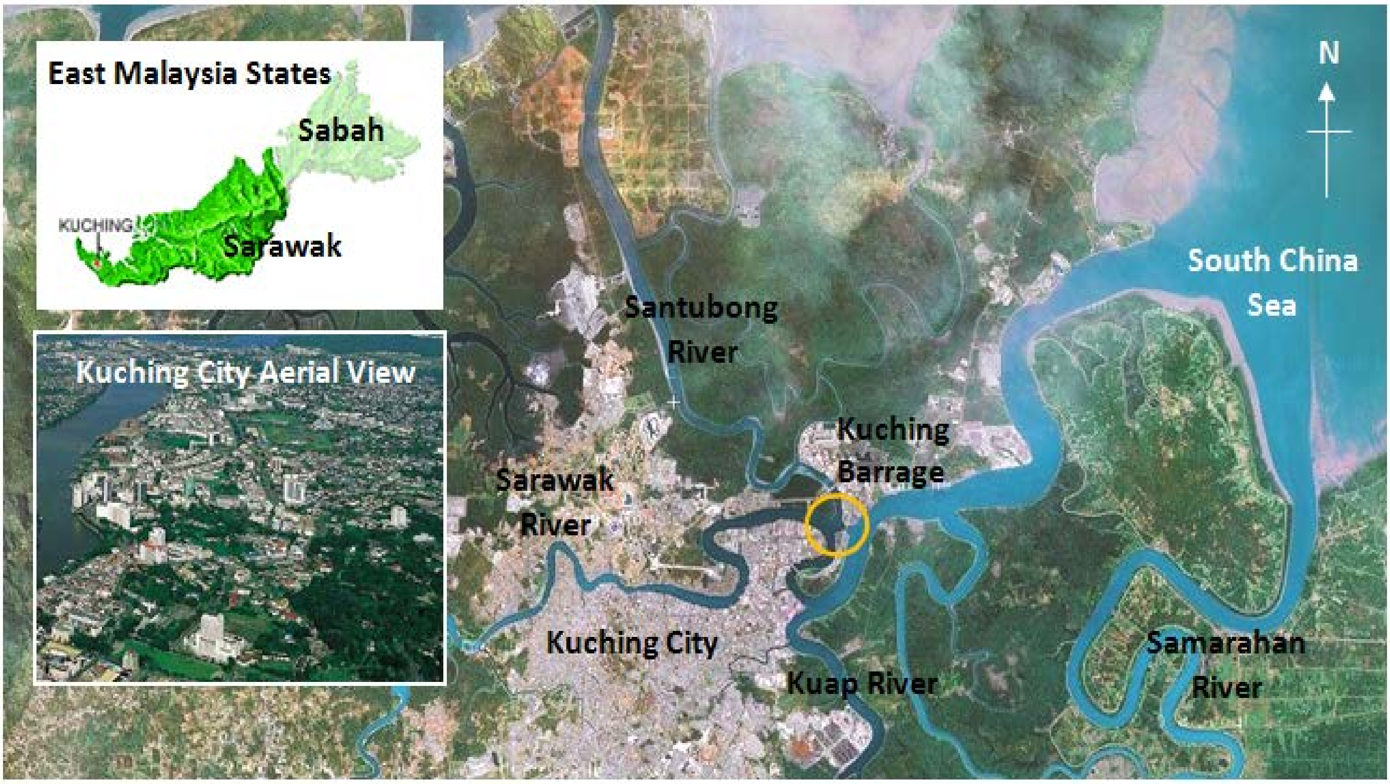

FIG. 1 LOCALITY OF KUCHING CITY (http://www.wikimapia.org)

Kuching Barrage was established just downstream of the city to curtail high tide. Inundations were reported the worst in 20 years within the vicinity of the city centre on January 11 (Sunday) where the South Bank central business districts were flood stricken. The following day (January 12, Monday with daily total rainfall of 11 mm) had seen the floodwater subsided as the weather cleared.

The responsible authorities would have collected the necessary flood data during the event. Such official report would take several weeks before being available. Civilian would need to go through several correspondences and procedures before being allowed to gain access to the report. The lack of details in the previous flood reports is revealled, for example the unknown flood depths at the exact location. The report only indicated one observation reading for one clustered common area where this may due to the lack of man power.

Surprisingly after the flood, a browse of the internet had seen a surge of bloggers sharing their experiences concerning the event. A camera phone was affordable and common among the public over this region. These bloggers had posted large quantity of photos according to their individual lifestyles of working places, certain routes they travelled on or residential areas they stayed. They had provided detailed accounts on the flooding of different corners of the city. This had prompted an interest in this paper to explore the potential of these unorthodox means of data on flood reconstruction.

Materials and Methods

After screening through numerous blog sites, two sites (Kuching-Catscity, 2009; My Dreamline, 2009) were found to provide reasonable footages of flooding along the Padungan Road; while one site (My Endless Story, 2009) depicted flooding in the Kuching Water Front areas. The photos are shown in Fig. 2. All three blogs had uploaded photos taken on January 11, the day of the peak inundation. However, the time of photos taken were not known. Hydrological monitoring stations of Sarawak River had indicated that the peak flood level occurred in the evening between 1600-2000 hours. In Kuching, the sky would be dark by 1830 hours. In Fig. 2, except the photos depicting locations 1, 7 and 8, the rest of the photos are featured in broad day light. Note also in the photos of locations 9 and 10, sign board lights were switched on indicating evening time. It is always a challenge to have the most ideal data. In the absence of additional photos on the Sunday evening, the authors were to presume those photos as the maximum inundation of the captured areas.

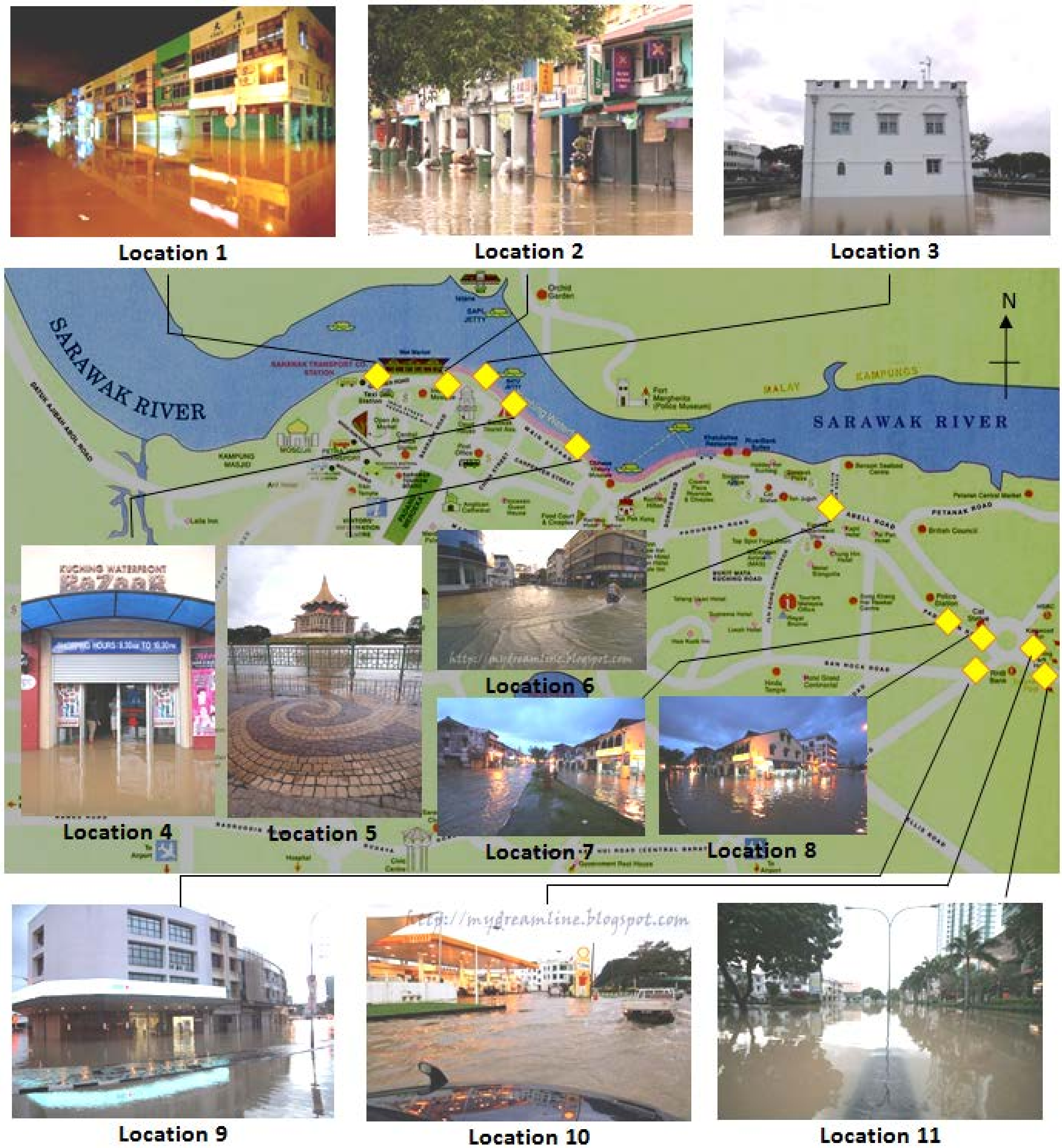

FIG. 2 KUCHING CITY MAP AND PHOTOS SHOWING EXTENT OF FLOODING IN VARIOUS LOCATIONS (BACKGROUND MAP COURTESY OF SARAWAK TOURISM BOARD)

Kuching Water Front is an urban renewal development program initiated in the early 1990s. This major restoration project has a 900 m long esplanade. Roads like Gambir Road, Abell Road and Padungan Road closely aligned to Sarawak River, as they formed the oldest parts of early establishment in Kuching where all houses were close to the river. When the floodwater subsided, smaller rainfall that persisted easily washed away any debris or marks. The road inundations were less than 1 m and therefore flood marks were barely noticeable. A field trip to the eleven locations assisted by the extracted photos and short interviews had allowed estimation of the flood depths conveniently, as tabulated in Table 1.

TABLE 1 LOCATIONS UNDER STUDY, ESTIMATION OF GROUND AND FLOOD LEVELS

Location	Description	Estimated Flood Depth (m)	Elevation (from GIS) (m)	Estimated Water Level of Sarawak River (m)
1	Shoplots, Gambir Road	0.70	Road Level +4.50	5.20 (for upstream end)
2	Shoplots, Barrack Road, beside Old Court House, junction to India Street	0.40	Road Level +4.80	
3	Square Tower, Kuching Water Front Esplanade	0.90	Ground Level +4.10	
4	Water Front Bazaar, Kuching Water Front Esplanade	0.60	Ground Level +4..40	
5	State Assembly Hall, Kuching Water Front	0.20	Esplanade Level +5.00	
6	Longhouse Hotel, Abell Road, junction to Padungan Road	0.10	Road Level +5.10	
7	Shoplots, Padungan Road	0.30	Road Level +4.90	
8	Shoplots, Padungan Road	0.30	Road Level +4.90	
9	RHB Bank, Padungan Road	0.60	Road Level +4.60	
10	Shell Petrol Station, Padungan Road	0.50	Road Level +4.70	
11	Kuching Park Hotel, Padungan Road	0.40	Road Level +4.80	5.20 (for downstream end)

Notes: Mean Sea Level = +4.5 m, Spring Tide Level often up to 6 m

Geographical Information System of Sarawak River Basin is available as reported in a local study (Said et al., 2009), where the system provided ground level information along the river corridor. The city centre was surveyed in great deals since 2003 when Malaysia adjusted its mapping system to Geocentric Datum of Malaysia (GDM2000) within 1 cm accuracy (JUPEM, 2009). The survey is to date limited to 27 km of the city stretches of Sarawak River (out of 120 km). The GDM2000 is defined on an International Terrestrial Reference Frame (ITRF2000) based on Global Positioning System (GPS) network. As such, the GIS of the Kuching city centre is considered adequate. GIS assisted in pinpointing the exact locations in the photos with known elevations, to which nearby surveyed floodwater depths were added to estimate river water levels.

The most straight forward way to reconstruct the Kuching city after flood in January 2009 in Kuching is to model Sarawak River. It is common nowadays that river model supported proper flood mapping. Flood mapping is a necessary step to identify areas at risk from surface waters in order to assist decision makers and urban planners in flood mitigation planning and floodplain management. The MWH Software model–InfoWorks River Simulation (RS) has been utilized in this project. Examples on the usage of InfoWorks RS in addressing fruitful flood mapping efforts are reported in Néelz et al. (2006) and Jenny et al. (2007). A full-length Sarawak River model has been developed. However, to meet the purposes of this project, only the city stretches of Sarawak River model was exploited while other parts of the model were remained dormant (see Fig. 3).

InfoWorks RS is a modelling package that combined Geographical Information System, hydraulic/ hydrology simulation engine and database management. The full dynamic model would need to calibrate one parameter, the roughness coefficient. In the case of InfoWorks RS, it would be the Manning's n values. For the city stretches of Sarawak River, Manning's n of 0.035 and 0.15 were calibrated and found adequate for the river channel and floodplain respectively. The model also requires that boundary conditions should be established before the starting of simulation.

The intended isolated river model had utilised the river water level estimated at Gambir Road as upstream end, and Padungan Road as the downstream end. River flow of 1034 m^3/s was computed by the model based on river channel geometry bounded by the estimated 5.2 m river water level and fed to the upstream end boundary to satisfy the computation requirement. The embedded GIS functionality in InfoWorks RS had computed an overbank flood extent map from Sarawak River (see Fig. 4 and Fig 5) based on bloggers' information on flood in January 2009.

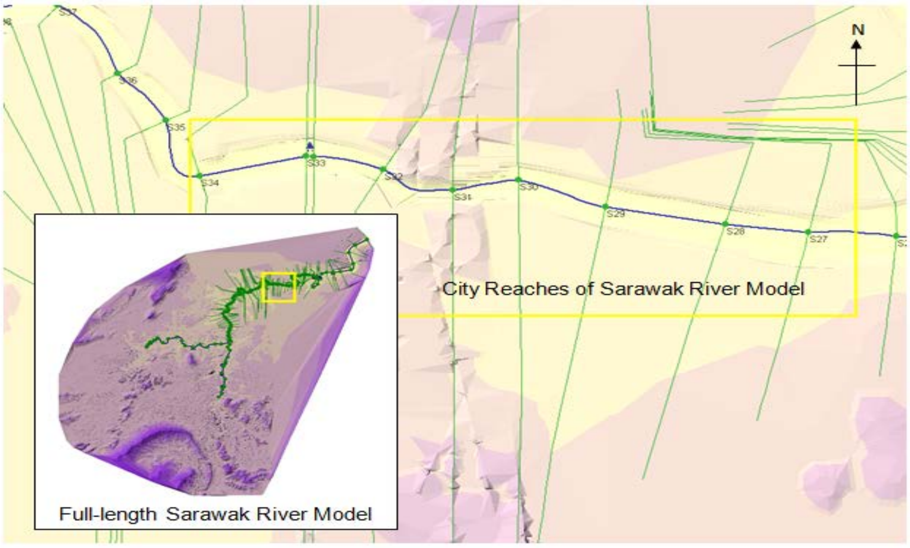

FIG. 3 SARAWAK RIVER MODEL

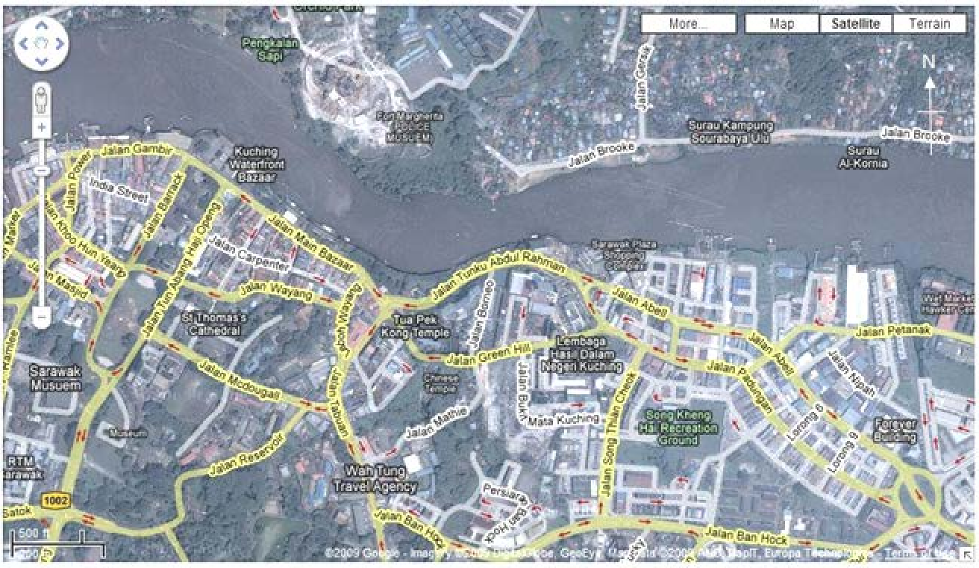

FIG. 4 SATELLITE IMAGERY OF KUCHING CITY STRETCHES OF SARAWAK RIVER (Note that *Jalan* is the local Malay language for Road) (http://maps.google.com.my)

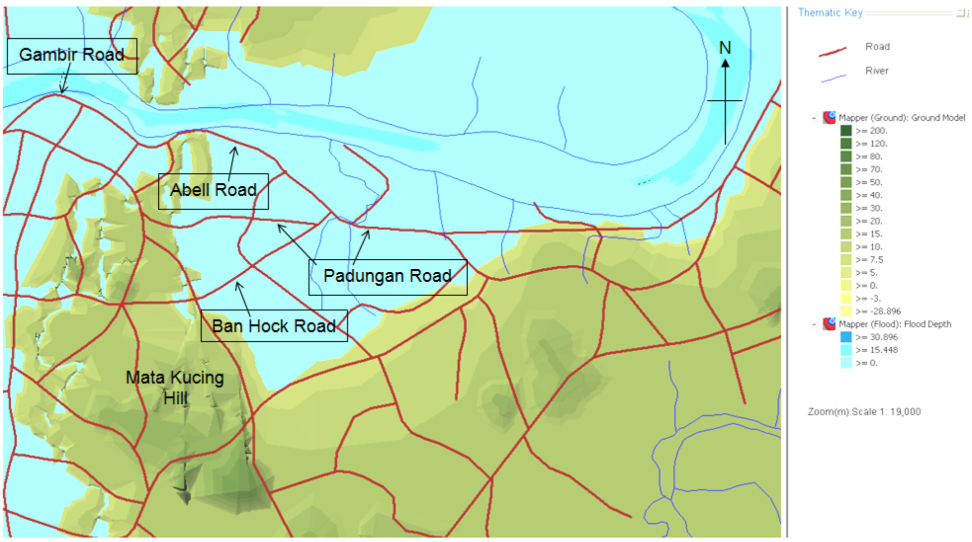

FIG. 5 JANUARY 2009 FLOOD EXTENT MAP FOR KUCHING CITY

Results and Discussion

Kuching Water Front Esplanade was raised to a higher level of +5.00 m. However, some structures along the esplanade were old buildings built in the colonial era. Therefore the elevations of the Square Tower (Location 3) and Water Front Bazaar (Location 4) were lowered 0.90 m and 0.60 m. The adjacent roads were lowered 0.20 to 0.30 m. During the flood in January 2009, the river water level reached the esplanade level (Location 5). Low areas along Gambir Road were submerged. Slight rise of water level in Gambir Road was damaging as the area was crowd with its textile shops.

Padungan Road was examined by review on the road kerb and island levels (Locations 7 to 11). The western stretches were less flooded where floodwater was below the road kerbs (Locations 7 and 8). Whilst the eastern stretches observed a floodwater levels above the road islands (Locations 10 and 11).

Kuching City is very flat. The South Bank commercial district from Gambir Road to Padungan Road bears a low gradient of 0.001 m/m. Based on that, the Sarawak River water levels were assumed to be the summation of the estimated flood depths and ground/road levels. The identified eleven locations are quite close to Sarawak River. For locations 1 to 5, the distance from the river perpendicular to the pinpointed spots range from 90 m to 100 m; location 6 is 260 m; locations 7 and 8 are 470 m and locations 9 to 11 are 500 – 510 m away. The locations furthest from the river are less than 1 km. Therefore, the estimated river water levels based on the mentioned assumption were reasonable. These data were used subsequent to the severe flood to simulate the flood event.

The estimated flood depths were compared to those computed from the river model, as tabulated in Table 2. The two sets of data bear differences ranged from 0.1 to 0.35. It is found that the differences are acceptable duo to the lack of the exact time at which the photos were taken. Guidelines concerning model validation on flood levels have been published. Some guidelines command strict sensitivity analysis of ±0.1 m between observed and modelled data (Whitlow, 1999), while some are moderate at allowing up to ±0.3048 m (1 ft) (USACE, 1993).

The concerns usually arise in the mapped flood zone on its uncertainties in (1) the magnitude of the flood discharge, (2) in the modelling of flood hydraulics, and (3) in the transformation of the modelled water surface elevation onto a map (US National Research Council, 2007). The bloggers' information is argued here as a source of data potentially to improve the third element.

TABLE 2 COMPARISON OF FLOOD DEPTHS

Location	Flood Depth From Bloggers (m)	Flood Depth (from River Model) (m)	Different (m)
1	0.30	0.541	+0.241
2	0.20	0.439	+0.239
3	0.90	0.825	+0.075
4	0.60	0.457	-0.143
5	0.00	0.111	+0.111
6	0.10	0.364	+0.264
7	0.30	0.436	+0.136
8	0.30	0.442	+0.142
9	0.60	0.819	+0.219
10	0.50	0.778	+0.278
11	0.40	0.749	+0.349

Urban flood risks could be proactively managed by taking advantage of interventions at a practical level (Zevenbergen et al., 2008). Recall of the flood event in January 2009 had proven the common usage of internet and camera devices (e.g. digital camera or camera cell phone) in the Kuching communities. This is a positive development as the bloggers would pour in more detailed information in comparison with the short-handed authorities. Incorporation of such trends in a flood information system framework could be developed involving authority-public participation. Currently those blog sites have provided excellent spatial data but not short of temporal data. The authority could provide a platform/website for the public to upload photos and some simple steps to induce the time of photos taken. With the known time of flood occurrence, a picture showing stage by stage of a flooding event is available. Nevertheless even without the exact time as demonstrated in this paper, with pictures of maximum inundation known at varied locations, it would still contribute tremendously to urban flood management.

Conclusion

"Blog" is a new vocabulary and a new lifestyle of this generation. The ability of bloggers to leave descriptions of events is highlighted and appreciated in this paper. Accurate flood information incurs a large burden on the logistics and cost of mapping other sources. However, dependent on the uploaded photos from blog sites as demonstrated, the potential of the computed flood hazard map is likely to be an easily-adopted alternative technique compared to other expensive earth surface observation methodologies.

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